The University of Georgia

College of Agricultural and Environmental Sciences
Cooperative Extension

Poultry Housing Tips

It is Difficult to Keep Birds Cool With Air Speed Alone

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Figure 1. Tunnel-ventilated commercial layer house

Digesting and metabolizing feed produces a considerable amount of heat. For instance, a five-pound-broiler produces roughly the same amount of heat as a 20 watt light bulb. Understanding how temperature, humidity, and wind speed affect a bird's ability to rid itself of excess heat is essential when trying to determine how best to manage a tunnel ventilation system during hot weather.

A bird rids itself of excess heat in primarily two ways: it gives off heat to the air around it (sensible heat loss) and it loses heat through the evaporation of water off of its respiratory system (latent heat loss). Sensible heat loss is fairly simple to understand. The bird's body is warmer than the air and therefore the bird loses heat to the air surrounding it. The cooler the air, the greater the amount of heat loss. The warmer the air, the lower the amount of heat loss. Latent, or evaporative heat loss, can be a harder concept to understand. As a bird breathes, moisture evaporates from the respiratory system. As this moisture evaporates, heat is removed from the bird just like the evaporative cooling pads "remove" heat from air entering a house during hot weather. As you might expect, the amount of heat a bird loses through the evaporation of moisture off of its respiratory system depends on the relative humidity of the air it breathes. The lower the relative humidity, the more moisture the bird can evaporate off of its respiratory system and the more heat that can be removed from the body. Conversely, the higher the humidity, the lower the amount of moisture evaporated from its respiratory system and the lower the amount of heat removed.

The total amount of heat being removed from a house during hot weather can be determined if one knows the temperature and relative humidity of the air entering and leaving a house, and the air exchange rate. Measuring temperature and relative humidity is fairly simple but determining air exchange rates accurately can be difficult. Another complicating factor is that we are not as interested in the total heat removed from the house as much as we are the portion removed from the birds.

In August of 2010, a short study was conducted in a 150,000 bird commercial layer house to examine how air temperature affects the heat loss from birds in a tunnel house during hot weather. The study was conducted in this specific type of house for a number of reasons. First, it was a very basic tunnel house. All the fans were in one end wall, and all the tunnel openings were in the opposite end wall. This made the house air exchange rate extremely uniform from wall to wall and from floor to ceiling. Secondly, the house had no evaporative cooling system. This was important because without an evaporative cooling system, the heat loss from the birds at high ambient air temperatures could be determined which would have not been possible had evaporative cooling pads been in use. Last but not least, this type of commercial layer house has a very high density of birds per cubic foot of house volume compared to a typical broiler house. This meant the heat gained through the walls and ceilings was insignificant (less than 1%) relative to that produced by the birds.

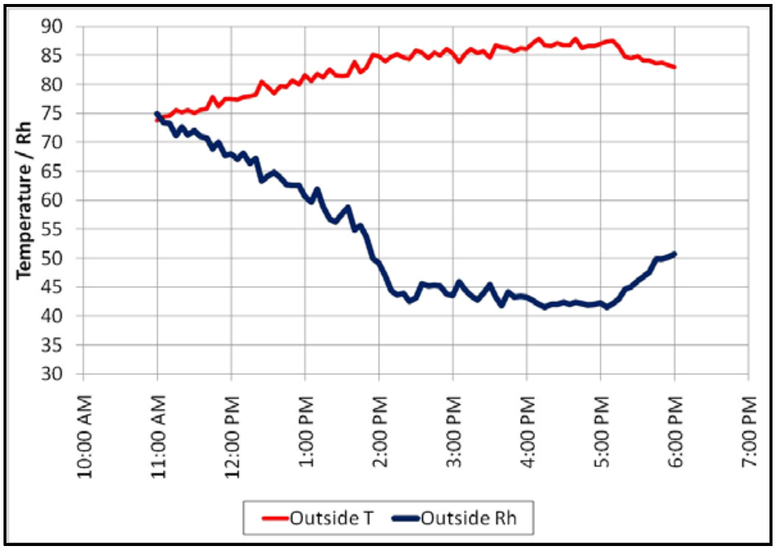

Figure 2. Outside conditions during study period.

Hundreds of air velocity measurements were recorded throughout the house which allowed both the average aisle velocity and air exchange rate to be determined. Air temperature and relative humidity measurements were recorded every five minutes at the inlet and exhaust ends of the house over the study period which lasted from 11 am to 6 pm (Figure 2). From these data, both sensible and latent heat removal from the birds were determined over the course of a fairly typical summer day.

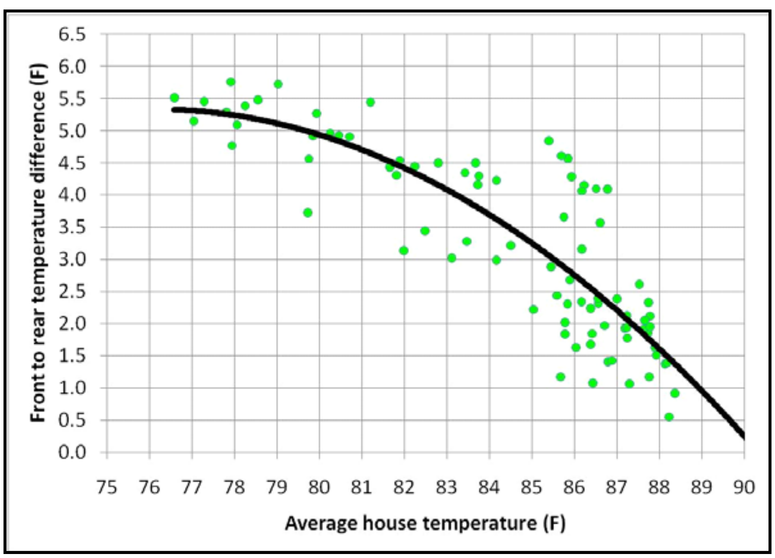

Figure 3. Temperature difference between inlet and exhaust ends

The difference in temperature between the inlet and exhaust ends of a tunnel house is an indicator of the heat removed from the birds through air movement. Assuming there is little heat being added to the air by house surfaces and the air exchange rate is constant (both of which were true in this instance), the greater the temperature difference, the greater the amount of heat removed from the birds. When the house temperature was in the mid seventies, the temperature difference was a little over five degrees. As house temperature increased, the temperature difference decreased which meant less and less heat was being removed from the birds by the warmer air moving down the house. This is not overly surprising considering that it is the difference between the bird's body temperature and the temperature of the air that determines bird cooling. The cooler the air, the greater the heat transfer from the bird's body to the air, the colder the bird feels. The warmer the air, the lower the amount of heat transferred from the bird to the air, the warmer the bird feels. By late afternoon, sensible heat loss was reduced by 80% which meant the air movement in the house was no longer producing a substantial amount of cooling.

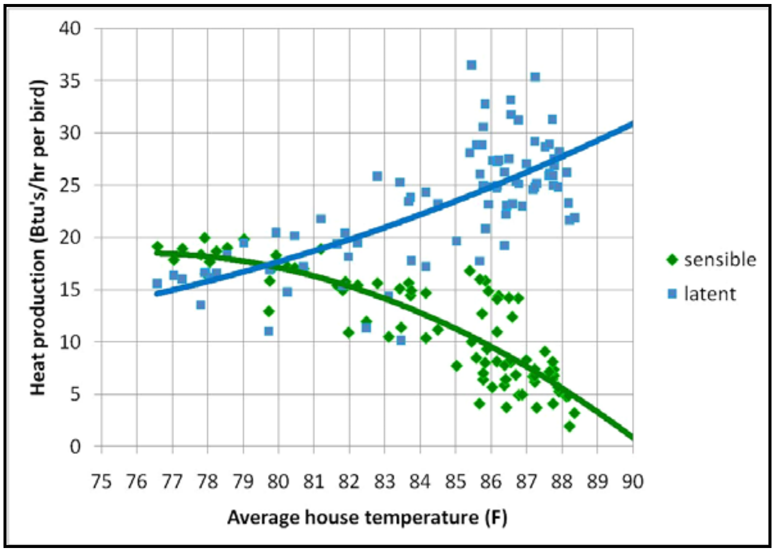

Figure 4. Sensible and latent bird heat removal

Even though the sensible heat loss was reduced by 80% as house air temperatures approached 90ºF, this didn't mean the total heat loss from the birds was reduced by 80%. As air temperature increases, and the heat loss to the air decreases, a bird will react by increasing heat loss through panting (latent heat loss). The warmer the air gets the lower the amount of heat loss and the harder a bird will pant in order to keep its total heat loss the same (Figure 4). As long as the total heat loss remains the same, the birds body temperature will not increase and performance will suffer significantly.

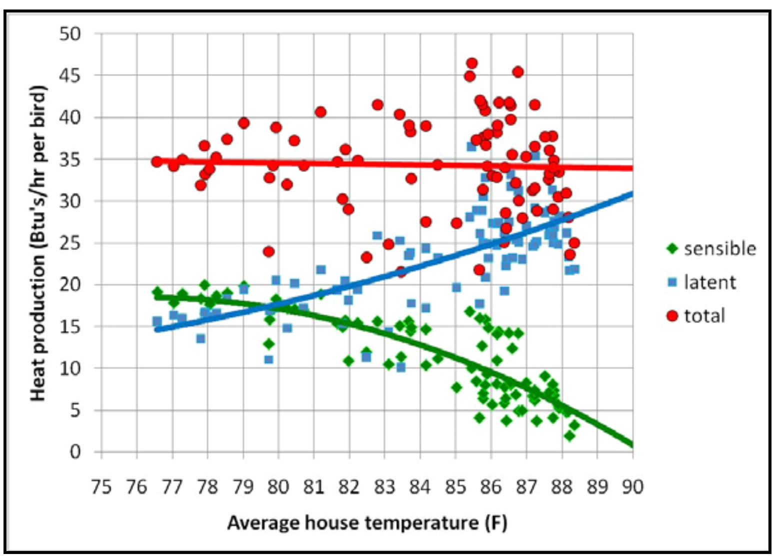

Figure 5. Sensible, latent, and total heat loss as a function of house air temperature.

Figure 5 shows the latent, sensible and total heat loss on a per bird basis. As house air temperature increases, the air flowing down the aisles of the house is less effective in removing heat from the birds, and the bird compensates by increasing the heat loss through the evaporation of water off its respiratory system, panting Though bird performance (i.e. feed conversion) may have suffered slightly due to the increased panting rate, the birds in the house appear to have been able to cope with the increased air temperatures by the fact that total heat loss appeared to remain relatively constant (trending slightly downward) as house temperature increased.

But, what would have happened had house temperatures continued to increase? From Figures 3, 4, and 5 it is not difficult to determine that somewhere around 90ºF the heat loss from the birds to the air would have essentially dropped to zero. Basically, the air speed in the house would no longer produce a cooling effect and the birds in the house would have to rely solely on panting to cool themselves. The problem is that panting, by itself, cannot remove all the heat being produced by the bird and as a result the total heat loss will drop more quickly and bird body temperature will start to rise more quickly as temperatures climb above 90ºF. Now it's a race against the clock. The longer the house temperature remains above the upper critical temperature of +90ºF range, the faster the bird's body temperature will increase, and the more likely performance will suffer.

How can bird heat removal be increased in this situation? One way is to increase the amount of air movement over the birds. At higher air temperatures the differential between the bird's body temperature and the air temperature decreases which means each cubic foot of air removes less heat from the bird. So, if each cubic foot of air removes let's say 20% less heat from a bird, we need to move 20% more cubic feet of air over the birds to compensate. This is the primary reason that as air temperatures increase we need to operate more tunnel fans to produce the same amount of cooling. But, it is important to realize that increasing air movement/fan capacity would only work to a point. Eventually the house air temperature will get close enough to the bird's body temperature that increasing air movement would not longer be of any benefit.

The other method of increasing total heat loss would be to decrease air temperature through the use of evaporative cooling. The lower air temperature brought about by an evaporative cooling system increases the effectiveness of the air moving over the birds to remove heat from the birds. But that comes at a price - evaporative cooling increases relative humidity. In fact for every 1ºF of cooling, the relative humidity of the air will increase roughly 2.5%. As a result though the lower air temperature would increase the effectiveness of air movement removing heat from a bird, the bird's ability to cool itself through the evaporation of water off its respiratory system (latent heat) would be reduced. In the end, the bird would feel cooler but not as cool had the house temperature gone down because of the sun going down or a cold front moving through. Let's look at an example. If it were 82ºF in the morning, the heat loss would be three times greater compared to the late afternoon when the temperature was 88ºF. Had an evaporative cooling system been used to decrease the late afternoon air temperature to 82ºF, total bird heat removal may have only increased half as much because of the fact that the relative humidity would be higher which would decrease the birds respiratory heat loss. That is the challenge with using evaporative cooling to lower house temperatures. On one hand it increases our ability to remove heat from a bird. On the other, it lowers a bird's ability to cool itself through panting. How effective evaporative cooling is in reducing heat stress is a function of the amount of air movement over the bird. The higher the air velocity, the more a bird benefits from the lower air temperature produced by an evaporative cooling system. The lower the adverse affects of the higher relative humidity would be because the bird would be somewhat less dependent upon air movement for removal of excess heat.

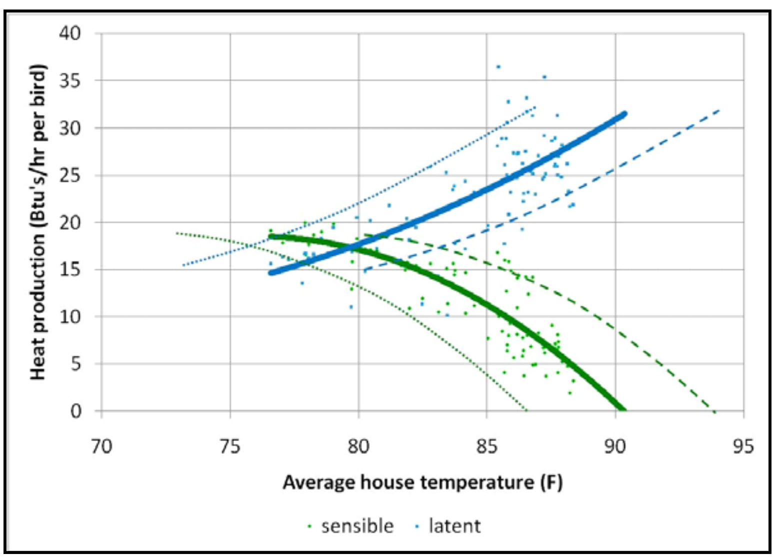

Figure 6. Sensible and latent heat loss as a function of house temperature.

In this particular case, 90ºF appeared to be the upper critical air temperature, but it is important to realize that it would change with factors such as air velocity, relative humidity, bird size, bird age, etc. In a house with large broilers with an air speed of 300 ft/min, the critical temperature would have been significantly lower. With young birds on a day with very low humidity, the upper critical temperature would have been higher (Figure 6). Another point to keep in mind is that how well a bird can cope with an upper critical temperature situation is also a function of bird size. A commercial layer may weigh a very lean 3 ½ pounds, and as a result can shed itself of excess heat fairly quickly when temperatures start to fall so it is better able to cope with an upper critical house temperature. A heavily muscled broiler can weigh twice as much, produce substantially more heat per pound, and sit on a well insulated floor; all of which can make lowering its body temperature after an upper critical temperature is reached very difficult

What does this mean in terms of bird management?

1) The amount of cooling produced through air movement is a function of air temperature. The amount of cooling the air movement in your tunnel house produces at 90ºF is substantially less than what is being produced at 80ºF. During hot weather make sure you run sufficient fans at night, when temperatures are relatively low, to remove built-up heat from your birds.

2) The cooling effect produced through air movement in a tunnel house tends to decrease rapidly between 85ºF and 90ºF. Make sure your evaporative cooling system is properly maintained so that you can maintain as low of a temperature as possible during hot weather. A few degrees of cooling can make a big difference as house temperatures approach 90ºF.

3) Most "wind chill" charts are for a house temperature between 80ºF and 85ºF. Since the cooling produced through air movement decreases rapidly as temperatures rise above 85ºF, "wind chill" charts tend to over estimate bird cooling at temperatures above 85ºF.

4) Evaporative cooling helps to increase the cooling produced through air movement but reduces the bird's ability to cool itself through panting. The higher the air speed in the house, the less a bird will be adversely affected by the humidity produced by evaporative cooling. To maximize bird cooling make sure you operate ALL your tunnel fans before using your evaporative cooling system.

5) With older birds as house temperatures approach 90ºF, you can't have too much air speed.

Michael Czarick
Extension Engineer
(706) 542-9041
mczarick@uga.edu
www.poultryventilation.com

Brian Fairchild
Extension Poultry Scientist
(706) 542-9133
brianf@uga.edu